

Andrei's work, 1 Apr 2014

CCD Instrumental Signatures

Gary Bernstein (UPenn) & Andrei Nomerotski (BNL)

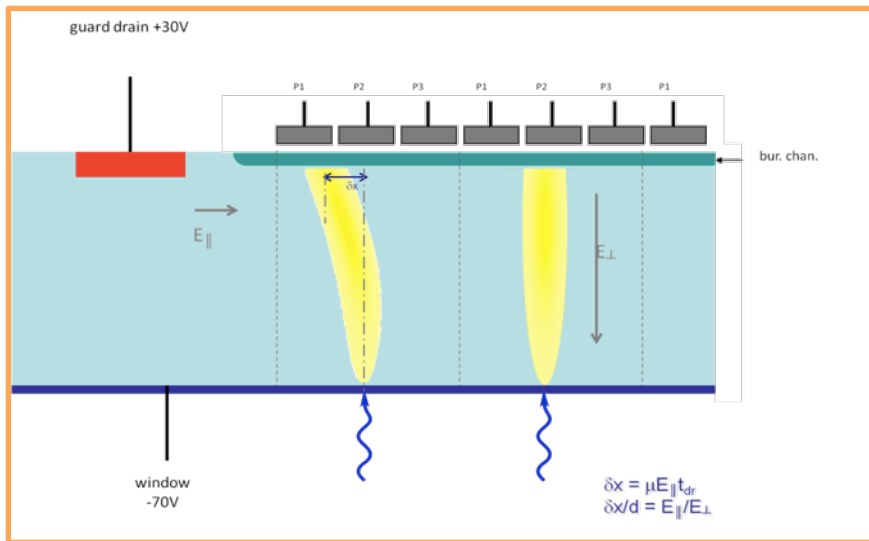
DES-LSST meeting, Fermilab, 24 March 2014

What's the problem with thick CCDs?

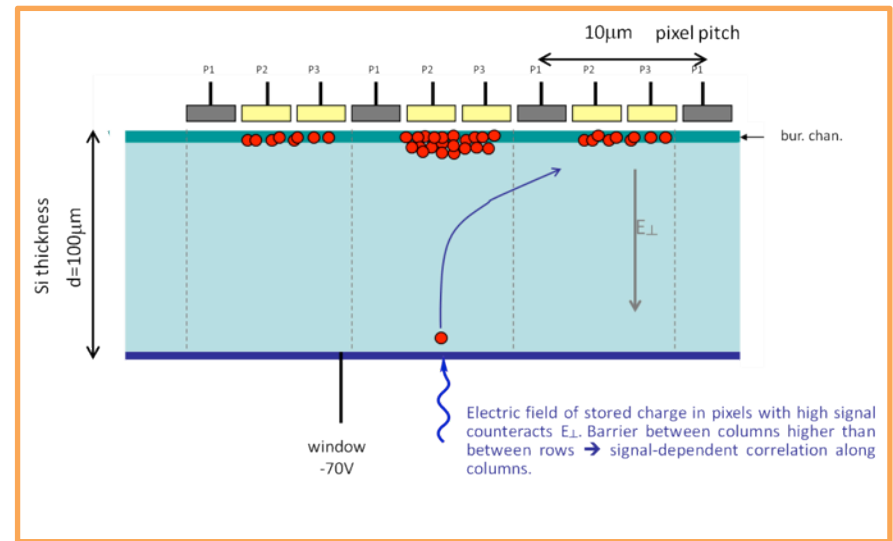
Electrostatics in semiconductor

Electric field lines inside CCD are not straight →
pixels change their size and shape

Static : edge effects, tree-rings



“Dynamic” : brighter-fatter effect

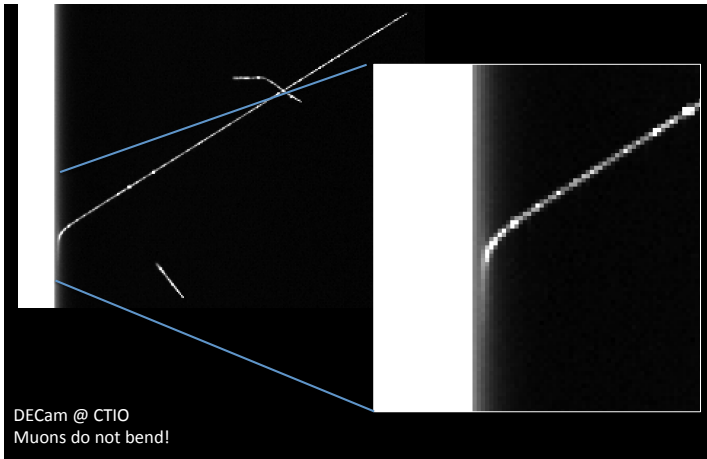


Andrei's talk Outline

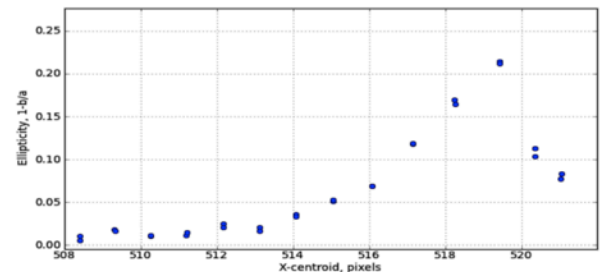
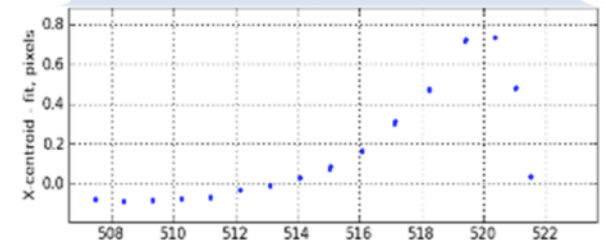
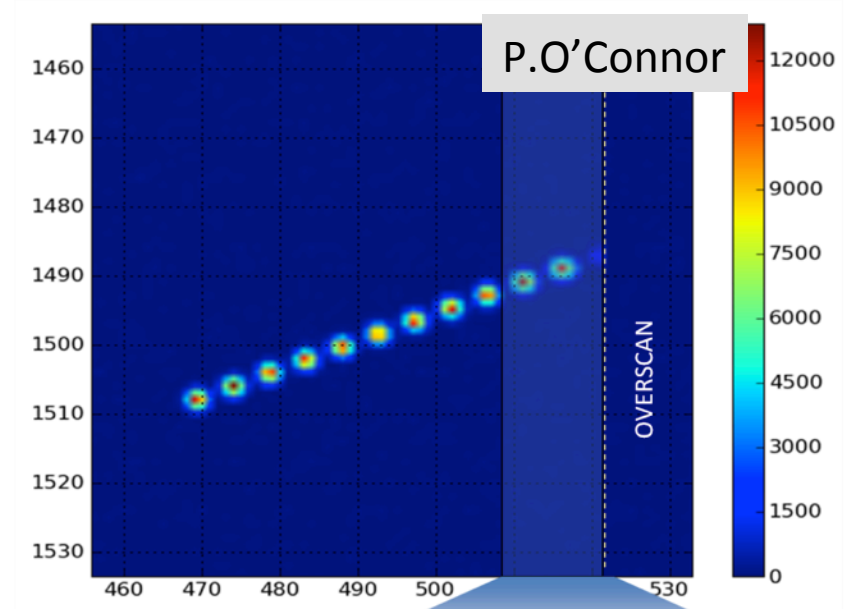
- Instrumental effects related to sensors
 - Brighter Fatter, tree rings and edge effects
- How we plan to address this in LSST
 - Lab measurements
 - Simulations of sensor effects
 - Systematics due to sensor effects

Edge Effects in CCDs

- On the egde:
 - Non-linearity up to 50%
 - Ellipticity up to 20%
- DES saw similar effects
 - Also for cosmic muons

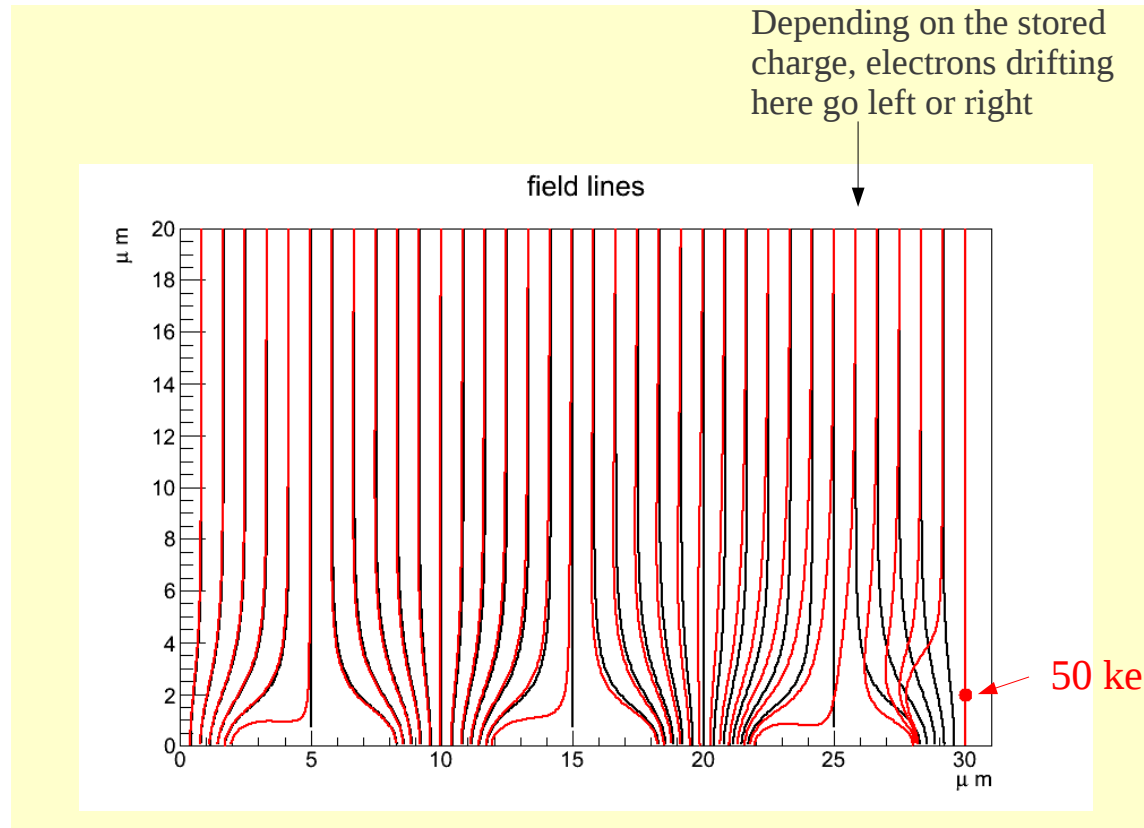


J.Estrada

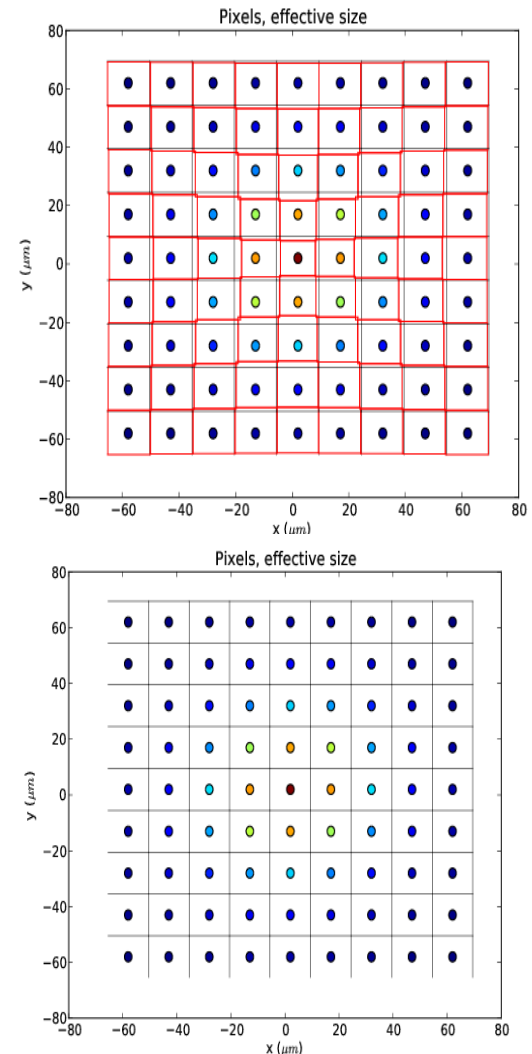


Brighter-Fatter Effect and Pixel Correlations

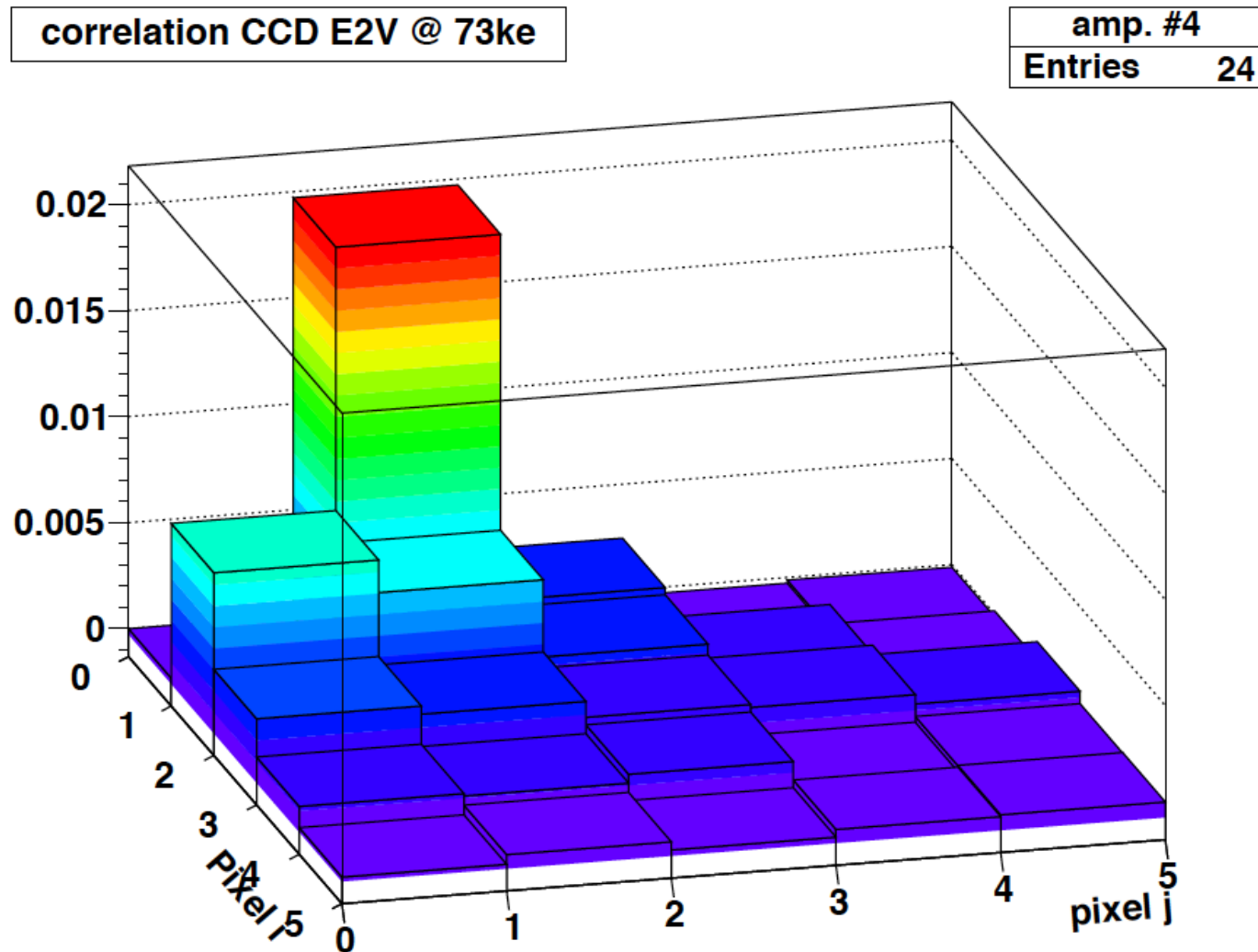
- Phenomenological approach using parameters from correlation matrices, can provide corrections



P.Astier

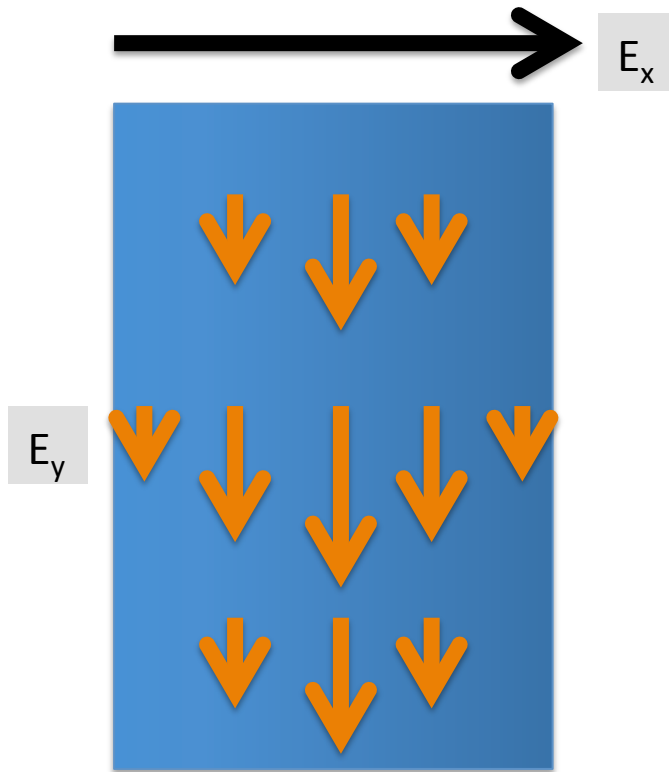


Signal Correlation in Neighbouring Pixels

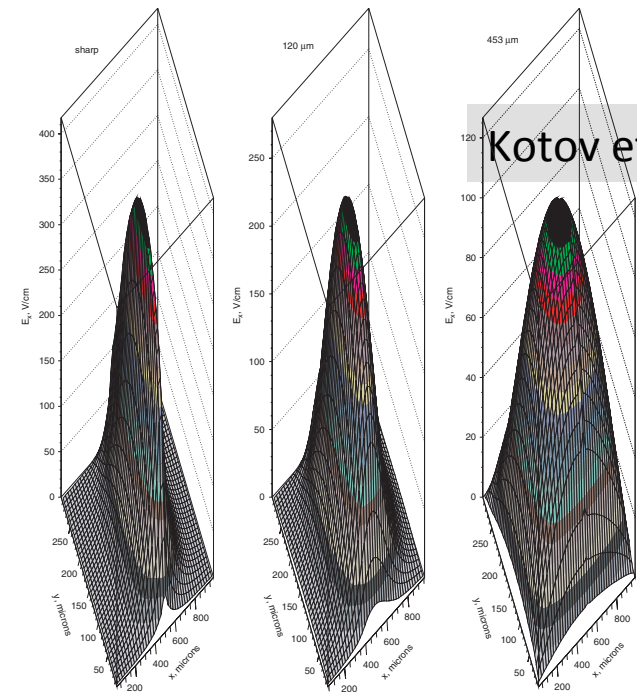
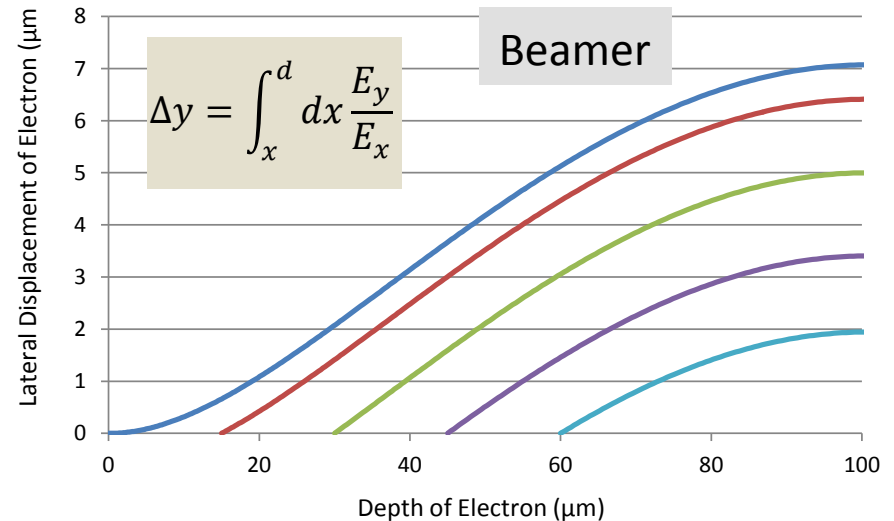


2-d autocorrelation at 73Ke, half of full well depth, (Harvard & IN2P3 analysis)

Lateral E Field from tree rings



Proper electrostatic simulations can be done but need to know sensor geometry/doping

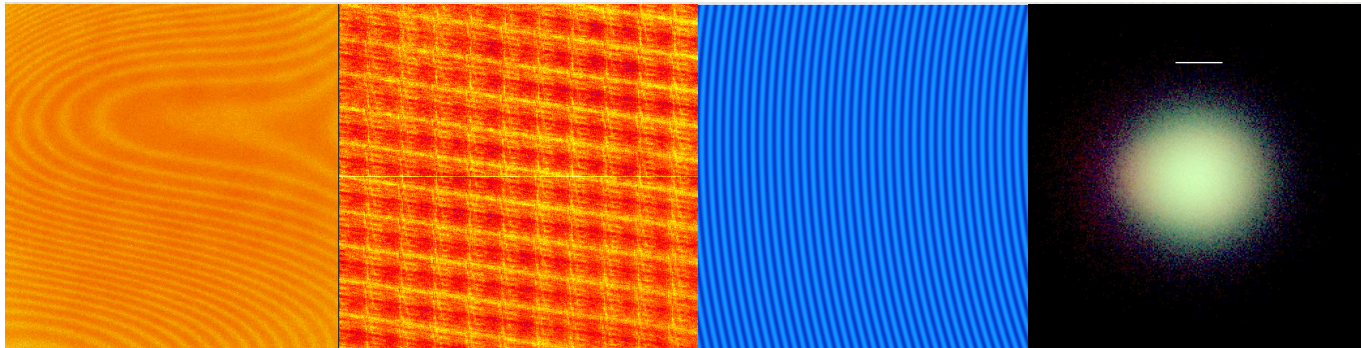


Kotov et al, 2006

Fig. 3. The E_x component for "sharp" and Gaussian transitions of the doping profile.

LSST: sensor simulations with Phosim

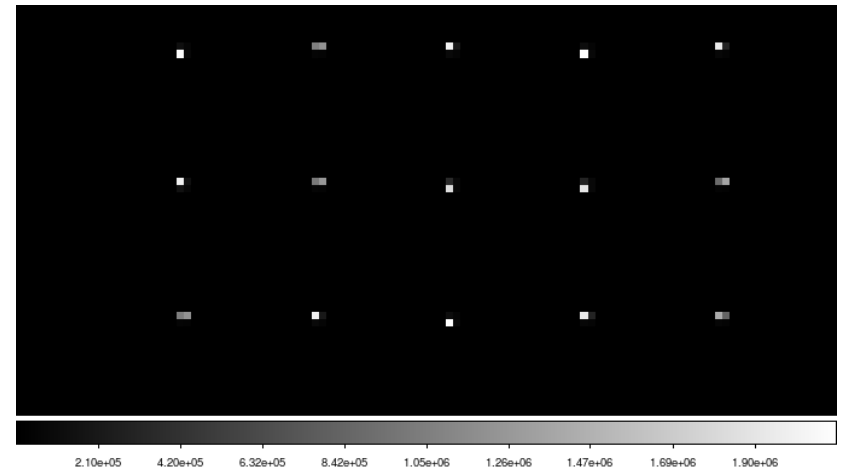
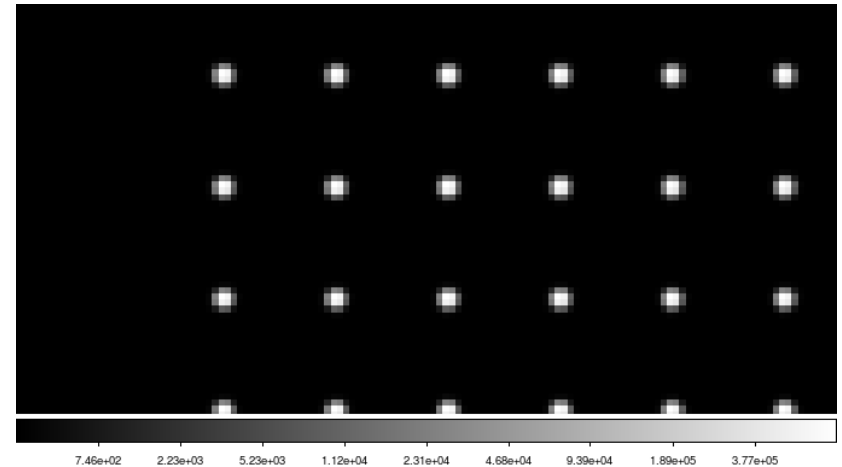
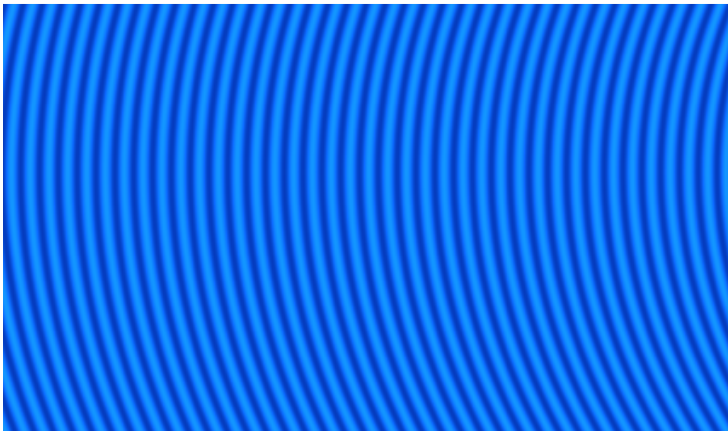
- Phosim (J.Peterson et al) : simulating telescopes one photon at a time
 - Instrumental effects include atmosphere, optics and sensors
- Good way to connect sensors to precision astrophysics
- Validate sensor part by simulations of lab setups and comparison to measurements
 - Most of sensor effects are now implemented in Phosim



Use tuned simulations to evaluate sensor effects on science (can turn physics on/off)

Current work on sensor effects in Phosim

- Code development (J.Peterson et al)
- Brighter-Fatter effect (Duke)
- Tree rings (BNL)
- Description of lab setups at UC Davis and BNL



Tools

- Phosim
- DM stack
 - Synergy with fast camera project

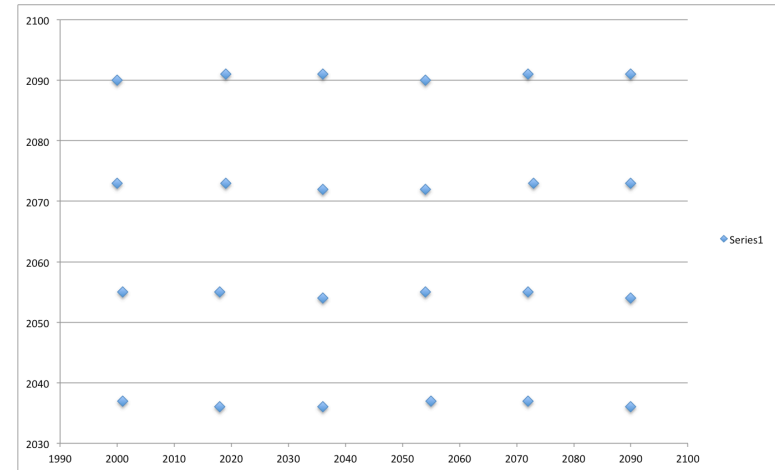
sExtractor →

PSFex →

Possibly Erin's
code for shear calculation

All installed at the cluster

#	1	NUMBER	Running object number		
#	2	FLUX_ISO	Isophotal flux	[count]	
#	3	XPEAK_IMAGE	x-coordinate of the brightest pixel	[pixel]	
#	4	YPEAK_IMAGE	y-coordinate of the brightest pixel	[pixel]	
#	5	A_IMAGE	Profile RMS along major axis	[pixel]	
#	6	B_IMAGE	Profile RMS along minor axis	[pixel]	
1	2351835	2090	2036	0.771	0.742
2	2353493	2072	2037	0.819	0.761
3	2352875	2055	2037	0.866	0.735
4	2353452	2001	2037	0.870	0.736
5	2351604	2036	2036	0.807	0.749
6	2353907	2018	2036	0.814	0.750
7	2355640	2090	2054	0.773	0.742
8	2353266	2036	2054	0.767	0.740

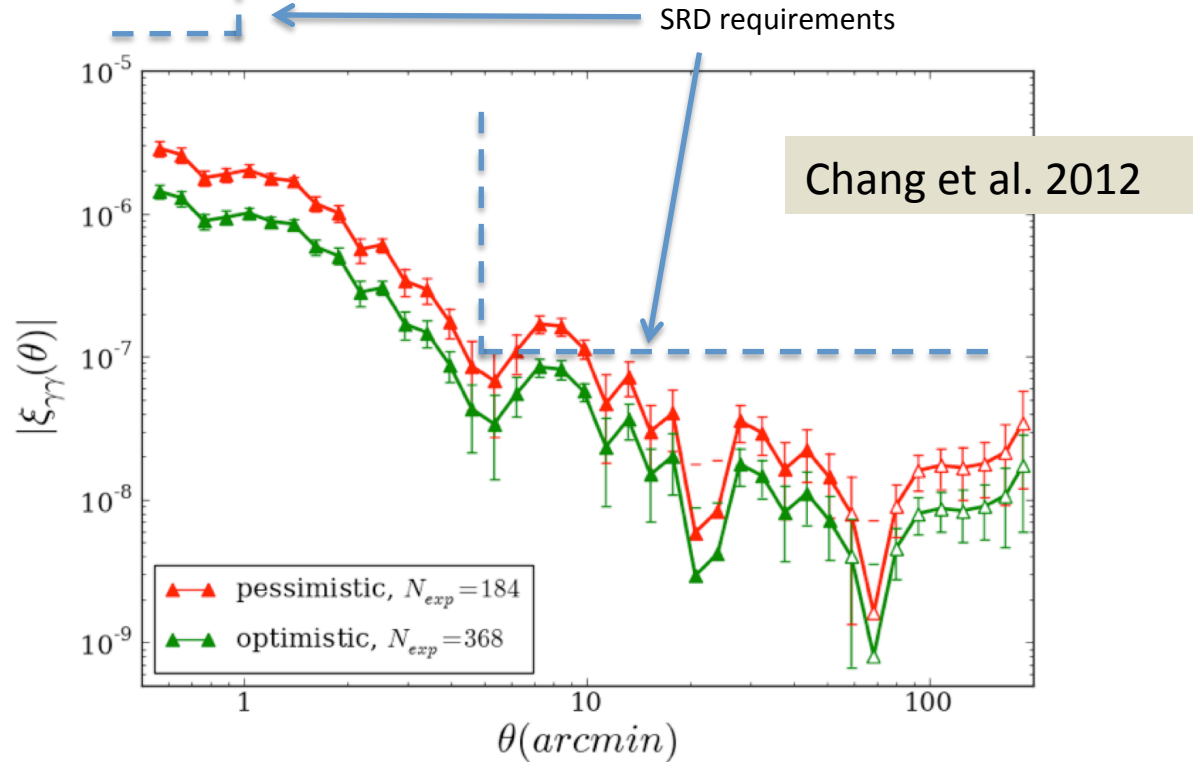


Organization/Plans

- Regular Phosim meetings/tutorials
- DM testing software meetings
- LSST project sensor/raft meetings
- Science plans
 - PSF chromatic effects due to sensors
 - Spurious shear due to sensors
- Goal – present first relevant WL results by summer at DESC meeting

More

Example: Evaluating contributions to shear



Absolute spurious shear correlation function after combining 10 years of r- and i-band LSST data; PSF knowledge from polynomial interpolation of stars

Requirements for weak lensing : shear correlation systematics are controlled to $\sim 30\%$ of the stochastic levels, or $< 2 \times 10^{-5}$ for $\theta < 1'$ and $< 1 \times 10^{-7}$ for $\theta > 5'$.

Fringes

- Interference patterns due to reflections off the sensor bottom, visible at longer wavelengths
- Use a random surface with some flatness
- Will use BNL metrology data to validate
- Assumes that the backside is flat
 - Fringe data at different wavelengths should allow to extract the backside flatness

